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(54) Title of Invention: **CONTACT EXPOSURE SYSTEM**

(57) Abstract

**PURPOSE:** To provide a contact exposure system that reduces the film thickness of an immersion liquid, which reduces the amount of light absorbed thereby and reduces and prevents exposure unevenness.

**CONSTITUTION:** A contact surface 11 of an exposure lens is hydrophilically treated with a hydrophilic solution, such as an alcohol. A wafer 3, which is coated with a photoresist 4, is brought into close contact with the hydrophilically treated contact surface 11 via an immersion liquid 5, and the irradiation of an irradiation light 6 transfers a pattern 7 of a photomask 1 onto the wafer 3. The hydrophilically treated contact surface 11 improves water absorbency and reduces the film thickness of the immersion liquid 5.

## **CLAIMS**

### **1. A contact exposure apparatus, wherein**

a wafer contact surface of a projection optical system or a photomask is hydrophilically treated;

the wafer, which is coated with a photoresist, is brought into contact with the hydrophilically treated contact surface via an immersion liquid; and

the irradiation of an irradiation light transfers a pattern of the photomask onto the photoresist.

## **DETAILED EXPLANATION OF THE INVENTION**

**[0001]**

## **INDUSTRIAL FIELD OF APPLICATION**

The present invention relates to an exposure apparatus that projects and exposes a pattern of a photomask onto a wafer in an LSI fabrication process, and more particularly relates to a contact exposure apparatus.

**[0002]**

## **RELATED ART**

With the kind of exposure apparatus that irradiates laser light and the like to project and expose the pattern of a photomask onto a semiconductor substrate, such as a silicon wafer, by using a projection optical system, four exposure systems are known: (1) a contact exposure system, (2) a proximity exposure system, (3) a reflection type projection exposure system, and (4) a reduction lens projection exposure system.

**[0003]**

Among these systems, the contact exposure system performs exposure by bringing the photomask (or the projection optical system) and the wafer into close contact, and the wavelength within the photoresist therefore is reduced by a factor of the inverse of the refractive index if they are completely in contact; consequently, the impact of diffraction is small and a high resolution transfer is obtained. However, there is a problem in that it is extremely difficult to realize complete contact; further, there is a problem in that the photomask and the wafer are mechanically brought into contact, and protrusions and the like on the front surface of the wafer therefore cause defects in the photomask, which reduces the life of the photomask while at the same time adversely impacting the yield of devices.

**[0004]**

Accordingly, a liquid (immersion liquid) is filled between the photomask and the wafer as a method to solve the problems caused by a contact exposure system. FIG. 2 shows a wafer that has been brought into close contact with a projection optical system; therein, 1 is the photomask, 2 is an exposure lens that constitutes part of the projection optical system, 3 is the wafer, which is coated by a photoresist 4, 5 is the immersion liquid, which is filled between the exposure lens 2 and the wafer 3, 6 is an irradiation light that irradiates a pattern 7 of a photomask 1 and exposes the photoresist 4, 8 is a holding body that holds the wafer 3, and 9 is a compression coil spring that urges the holding body 8 upward and pushes the wafer 3 against the exposure lens 2. The shorter the wavelength of the irradiation light 6, the lesser the impact of diffraction, and consequently a laser apparatus, such as an excimer laser, is used as the light source. It is preferable that the immersion liquid 5 has a refractive index approximately the same as the photoresist 4, absorbs little light, and does not dissolve the photoresist 4; normally, pure water is used.

[0005]

#### **PROBLEMS SOLVED BY THE INVENTION**

Nevertheless, in a contact exposure apparatus that uses the immersion liquid 5 as discussed above, there is a problem in that unevenness arises in the amount of the irradiation light 6 absorbed by the immersion liquid 5 if there is film thickness unevenness in the immersion liquid 5 itself, which unfortunately leads to portions where the pattern of the contact exposed photoresist 4 is precisely exposed and portions where it is not. Accordingly, to prevent the occurrence of such exposure unevenness, it is preferable to reduce a film thickness  $d_1$  of the immersion liquid 5, as well as to reduce unevenness in the absorption of light thereby.

[0006]

The present invention considers the problems and needs of the conventional art discussed above, and it is an object of the present invention to provide a contact exposure apparatus that can reduce the film thickness of the liquid as well as reduce and prevent exposure unevenness.

[0007]

#### **MEANS FOR SOLVING THE PROBLEMS**

To achieve the abovementioned objects, the present invention hydrophilically treats a wafer contact surface of a projection optical system or a photomask, brings the wafer, which is coated with a photoresist, into contact with the hydrophilically treated contact surface via an immersion liquid, and transfers a pattern of the photomask onto the photoresist by the irradiation of an irradiation light.

[0008]

#### **MODE OF OPERATION**

In the present invention, the film thickness of an immersion liquid is reduced by improving the water absorbency of the surface of a hydrophilically treated projection optical system or photomask that contacts a wafer.

[0009]

## **EMBODIMENTS**

The following explains the present invention in detail, based on the embodiments shown in the drawings. FIG. 1 is a cross sectional view of the principle parts of one embodiment of a contact exposure apparatus according to the present invention. Furthermore, constituent parts that are identical to those in FIG. 2 are assigned the same symbol, and the explanations thereof are omitted. The present embodiment describes a case wherein a wafer is brought into close contact with a projection optical system; in this case, a wafer contact surface 11 of an exposure lens 2, which constitutes part of a photomask projection optical system, is hydrophilically treated in advance, a wafer 3 is brought into close contact with the hydrophilically treated contact surface 11 via an immersion liquid 5, such as pure water, and the irradiation of an irradiation light 6 transfers a pattern 7 of a photomask 1 onto the wafer 3.

[0010]

The hydrophilic treatment is performed by neatly wiping the contact surface 11 with a hydrophilic solution, such as an alcohol, to remove impurities from the lens surface. Furthermore, the wafer 3 is brought into close contact with the post-hydrophilically treated contact surface 11 via the immersion liquid 5, and a spring 9 then presses the wafer 3 to the exposure lens 2 at a prescribed pressure.

[0011]

Thus, in such a constitution, the hydrophilic treatment improves the water absorbency of the contact surface 11, which enhances the water absorbency effect of the immersion liquid 5 compared with the case when hydrophilic treatment is not preformed, and accordingly decreases the surface tension and improves the wettability of the immersion liquid 5; consequently, it is possible to reduce a film thickness  $d_2$  of the immersion liquid 5 ( $d_2 < d_1$ ), compared with the conventional apparatus shown in FIG. 2; in addition, the lesser the film thickness, the lesser the amount of absorbed light, and therefore it is possible to reduce the unevenness in the absorption of light in proportion to the film thickness, and to reduce and prevent exposure unevenness.

[0012]

## **EFFECTS OF THE INVENTION**

The contact exposure apparatus of the present invention as explained above is constituted so that the surface of a projection optical system or a photomask that contacts a wafer is hydrophilically treated, and the wafer, which is coated with a photoresist, is brought into close

contact with the hydrophilically treated contact surface via an immersion liquid, and it is therefore possible to reduce the surface tension of the immersion liquid itself and to thereby improve wettability. Accordingly, it is possible to reduce the film thickness of the immersion liquid; in addition, the lesser the film thickness, the lesser the film thickness unevenness of the immersion liquid, which makes it possible to reduce the absorption of the light and to reduce and prevent exposure unevenness caused by the immersion liquid.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a cross sectional view of the principle parts of one embodiment of a contact exposure apparatus according to the present invention.

FIG. 2 is a cross sectional view of the principle parts of a conventional example of a contact exposure apparatus.

## **EXPLANATION OF SYMBOLS**

- |    |                   |
|----|-------------------|
| 1  | Photomask         |
| 2  | Exposure lens     |
| 3  | Wafer             |
| 4  | Photoresist       |
| 5  | Immersion liquid  |
| 6  | Irradiation light |
| 7  | Mask              |
| 11 | Contact surface   |